Contract Number: W9132T-04-C-0013

Offeror's Name: Montana State University-Billings

Proton Exchange Membrane Fuel Cell Demonstration, Montana Army National Guard, Billings Armed Forces Reserve Center

Proton Exchange Membrane (PEM) Fuel Cell Demonstration
Of Domestically Produced PEM Fuel Cells in Military Facilities

US Army Corps of Engineers
Engineer Research and Development Center
Construction Engineering Research Laboratory
Broad Agency Announcement CERL-BAA-FY03

Montana Army National Guard
Billings Armed Forces Reserve Center
Billings, Montana 59102

April 29, 2004

Executive Summary

The Center for Applied Economic Research at Montana State University-Billings proposes to install and operate one (1) fuel cell system for the Montana Army National Guard. The fuel cell manufacturer is Plug Power of Latham, New York. Project subcontractors include the following organizations: Montana-Dakota Utilities (gas supply, unit installation, commissioning and maintenance), Ace Electric (wiring and interconnection) and Wagner Mechanical (plumbing and water management). The Plug Power unit we wish to demonstrate is a GenSys™ 5CS, rated at a maximum output of 5kW. Our plan is to operate the unit at 50% of capacity, or at 2.5kW.

The unit will be configured to serve a portion of the base electrical load at the Billings Armed Forces Reserve Center, located in Billings, Montana. It will be fueled by natural gas and operate in parallel with the existing grid-supplied power. The project is configured for heat recovery.

The host site point of contact is Major Mike Bricker. Major Bricker may be reached at: Michael.bricker@mt.ngb.army/mil.

The benefits of this project are multiple. Two primary benefits are gauging unit performance under what may be considered as extreme environmental conditions and the second is educational. Well thought-out and extensive mechanisms must be installed to maintain the flow of water into, through and out of the unit. Water management during extended periods of subzero temperatures will provide a challenge to the team. Secondly, many of the team members have expressed a strong desire to learn about the technology and are eager to participate in a successful demonstration. This would be a positive experience for Montana.

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Proposal – Proton Exchange Membrane (PEM) Fuel Cell Demonstration of Domestically Produced Residential PEM Fuel Cells in Military Facilities

1.0 Descriptive Title

Proton Exchange Membrane Fuel Cell Demonstration at the Billings Armed Forces Reserve Center, Montana Army National Guard, Billings, Montana (Mountain Geographic Region).

2.0 Name, Address and Related Company Information

Montana State University-Billings
Center for Applied Economic Research
1500 University Drive
Billings, MT 59101
(406) 657-1763

Data Universal Numbering System (DUNS) Number: 079713608
Taxpayer Identification Number (TIN): 816001642

Montana State University-Billings (MSU-B) is a comprehensive, regional, public university serving the educational needs of Montanans and is accessible to all who are qualified. MSU-B is an affiliate of the Montana State University family of campuses and has a student body of approximately 4,800. MSU-B is located in the largest city in Montana, Billings, which has a regional population of 123,000.
The Center for Applied Economic Research is a research and service organization for MSU-B. Its mission is to provide research and analysis to support economic development in the Yellowstone region that includes central and eastern Montana and northern Wyoming. The Center provides research services in energy markets and technology through grants, industry partnership agreements, collaborative studies, and customized contracts. Our website is www.msubillings.edu/caer.

3.0 Production Capability of the Manufacturer

Plug Power, Inc.

Plug Power designs, develops and manufactures on-site electric power generation systems utilizing Proton Exchange Membrane (PEM) fuel cells for stationary applications. Plug Power's fuel cell systems are expected to be sold globally through a joint venture with General Electric and through DTE Energy Technologies in a four-state territory, which includes Michigan, Illinois, Ohio and Indiana. The Company's headquarters are located in Latham, N.Y., with offices in Washington, D.C., and The Netherlands. Plug Power's role in the Program will be to serve as fuel cell manufacturer and provide technical and operational support to Montana State University and its service provider.

Plug Power's manufacturing facility in Latham, New York opened in February 2000 and is comprised of 50,000 square feet of dedicated production and production test facilities. Plug Power employs approximately 100 personnel in its production areas. The production processes are designed around the principles of Lean Manufacturing, and use the Toyota Production System as a model. As such, planning and production is via a "pull system" that is, systems are produced only as orders pull demand for product through the production system. Lead-time for delivery is twelve weeks for large orders; smaller orders can be fulfilled immediately.

Plug Power Background

Plug Power Inc. is a designer, developer, and manufacturer of on-site, energy generation systems utilizing proton exchange membrane fuel cells for stationary applications. The Latham, N.Y.-based company was founded in 1997 as a joint venture of DTE Energy Company and Mechanical Technology Incorporated. Plug Power Holland was established in February 2000 as the first European presence of Plug Power. Plug Power's fuel cell systems for residential and small stationary commercial applications are expected to be sold globally through a joint venture with the General Electric Company, one of the world's leading suppliers of power generation technology and energy services. DTE Energy Technologies will distribute these units in Michigan, Illinois, Ohio and Indiana. Systems will be distributed in Europe through Vaillant.

Our primary contact at PlugPower is:

Mr. Brian Davenport, PE
518-782-7700 x1939
brian_davenport@plugpower.com

The items and services to be provided by PlugPower include the following:

Quantity	Description
1	GenSys 5CS fuel cell system with Standby Capability (“Product”)
1	Service Agreement for Parts and Support
1	Shipment of GenSys 5CS and associated installation materials via flat-bed truck

4.0 Principal Investigator(s)

Mr. Brian Gurney
Energy Program Manager
Montana State University-Billings, Center for Applied Economic Research
Phone:(406) 657-2906 Fax: (406) 657-2327
Email: bgurney@msubillings.edu

5.0 Authorized Negotiator(s)

Dr. C.A. Carey
Director of Grants and Sponsored Programs
Montana State University-Billings
Phone: (406) 896-5872
Fax: (406) 657-2264
Email: cacarey@msubillings.edu

6.0 Past Relevant Performance Information

The Center is currently working on two distributed generation projects that involve fuel cells:

1. Solid Oxide Fuel Cell Demonstration Project
   Sponsor: Montana-Dakota Utilities
   Dollar Value: $400,000
   Point of Contact: John Delvo, (406) 896-4241
   Description: A partnership with Montana-Dakota Utilities, Global ThermoElectric and the Center for Applied Economic Research will result in the acquisition, installation, operation, maintenance, monitoring and removal of 2 SOFC's. The first unit will be a residential application while the second unit will be placed in a rural/remote setting.

2. Reducing Barriers to Distributed Generation
   Sponsor: Montana Department of Environmental Quality through a grant with the US Department of Energy
   Dollar Value: $100,000
   Point of Contact: Mark Hines, (406) 444-6769
   Description: The goal of this project is to identify a set of regulatory and business process best practices for the marketing, installation and servicing of small-scale distributed generation devices. One of the tasks in this project is to identify peculiarities with fuel cells, such as policies that encourage market adoption of fuel cell products through energy efficiency programs rather than renewable energy incentives. Simulations will be run to evaluate alternative business processes and identify best practices that minimize transaction costs associated with marketing, installing and servicing distributed generation units in residential and commercial settings.

3. Big Sky EDA Fuel Cell Project
   Sponsor: Big Sky Economic Development Authority
   Dollar Value: $54,000
   Point of Contact: Dan Stevenson, CTA, Inc. (406) 896-6171
   Description: Conducted analyses of the market for fuel cells, including a survey of households.

7.0 Host Facility Information

Military Facility Site 1:
Montana Army National Guard
Billings Armed Forces Reserve Center
2915 Gabel Road
Billings, Montana 59102

The Point of Contact is:
Major Michael Bricker, Officer in Charge
Billings Armed Forces Reserve Center
Phone: (406) 655-6220
Fax: (406) 655-6229
Email: michael.bricker@mt.ngb.army.mil

The State Facilities Management POC is:
Colonel Allan Stricker
406-324-3101
allan.stricker@mt.ngb.army.mil
and
Mr. Chris Denning, Operations Manager, MANG
406-324-3102
chris.denning@mt.ngb.army.mil

A frontal digital photo of the facility is included in Appendix **A**.

The facility's provider of electricity and natural gas are as follows:

Electricity: NorthWestern Energy
40 E. Broadway
Butte, Montana 59701

Interconnection POC:
Mr. Dave Ryan
406-497-2322
john.campbell@northwestern.com

Natural Gas: Montana-Dakota Utilities (MDU)
2603 2nd Ave. North
Billings, Montana 59101

MDU POC:
Mr. John Delvo, PE
406-896-4241
john.delvo@mdu.com

8.0 Fuel Cell Site Information

The site location is the Billings Armed Forces Reserve Center located in Billings, MT. The structure is approximately 6 years old and is constructed of pre-formed concrete panels. The facility is located in west Billings, in a commercial/industrial area of the city. The topography is relatively flat and is part of the Yellowstone River valley. The front range of the Rockies (i.e. the Beartooth Mountains) are located approximately 60 miles west. The Big Horn Mountains lie approximately 80 miles to the south. The utilities we need to access are located at the rear of the building. The natural gas, electricity and telecommunications infrastructure are located in very close proximity. (see photo in Appendix **B**). Directly abutting the external utility infrastructure is a "Mechanical Room." (see photo in Appendix **C**). The mechanical room will serve as the supply point for natural gas and water to the unit. The electrical load will be taken from the unit to the mechanical room where it will be fed to a bus on a panel that facilitates boiler operations for the structure. Additionally, hot water will be recovered and contribute to the heating needs of the structure.

We do not foresee any space constraints for the installation and the installation site appears to have adequate drainage.

The fuel cell provider is Plug Power of Latham, NY. The unit to be installed is a GenSys™ 5CS, Proton Exchange Fuel Cell and has a Power Output rated at 2.5 – 5kW. Our plan is to stay on the low end of operating capacity, operating at a set point of 2.5kW. There will be 1 fuel cell for this project.

Billings Armed Forces Reserve Center

- Designed in 1997-98
- Constructed in 1999
- 113,300 +/- square feet
- Facility is called the Billings Armed Forces Reserve Center
- Houses a US Marine Reserve Unit and 3 units from the Montana Army National Guard
- Facility includes spaces such as:
    - Messhall
    - Assembly Hall
    - Indoor Firing Range
    - Classrooms
    - Administrative spaces
    - Parachute drying tower
    - Military equipment supply rooms and weapons vaults
    - Etc.
- Anticipate constructing a 45,000 square foot addition to the building beginning within the next year +/-.

9.0 Electrical System

The fuel cell electrical system is dual function, capable of grid parallel and/or standby operation. This fuel cell installation will be operating in the grid parallel configuration. This is the standard operating mode of the fuel cell. The system generates power at a fixed set point and sends it to the facility. Unused power is sent to the grid or, if more power is needed, it will be taken from the grid. This is done by back-feeding a 50-amp breaker in an existing electrical panel. In this type of interconnection, if the grid fails, the system will safely isolate itself from the grid. Upon return of the grid, the system will synchronize itself and reconnect with the grid.

Fuel cell output is 120 VAC @ 60 Hz, single phase line to neutral with a separate ground. The system is considered a utility interactive current source which automatically synchronizes itself to the grid's voltage and frequency.

The fuel cell will be feeding an electrical panel in the mechanical room which serves the boilers, pumps, condensers and other mechanical equipment.

The fuel cell is rated for 5 kW (5 kVA) maximum, and 10 kVA for 5 seconds of overload conditions. The minimum set point is 2.5 kW (2.5 kVA). However, the system will follow any 0 to 5 kW load at the critical load panel in standby mode. The system has a unity power factor, pf = 1.0.

An automatic transfer switch is internal to the inverter which is designed to automatically isolate itself if over/under voltage is detected. Islanding protection is certified by Underwriters Laboratories to the UL 1741 standard.

The inverter has a microprocessor based controller that senses the grid, feeds the signal back and outputs the matching synchronized signal.

System controls are internal to the system and are designed and manufactured by Plug Power. These controls are microprocessor based. This fully integrated system is self controlling.

An Interconnection Agreement has been initiated by the project team and forwarded to the host sites' contracting office. When signed and dated by representatives of the host site, it will be forwarded to the local T&D provider, NorthWestern Energy. A 30-day review period for Interconnection Agreements is requested by NorthWestern and our plan is to have the agreement in place by 6/10/04.

Should the reader wish to review Interconnection Agreement template, it can be accessed at http://www.northwesternenergy.com/energy/renewables/renewable_energy.htm

10.0 Thermal Recovery System

1. Provide a complete description of the fuel cell thermal recovery system

What is the CHP heat recovery loop and can the system be operated without one installed?
The CHP heat recovery loop is a customer-supplied system that circulates a heat transfer fluid (typically propylene-glycol/water mixture) from the fuel cell to the customer-supplied system using the heat (baseboard heat, hot water tank, etc.) The fuel cell system is designed to operate normally if there is no CHP loop installed or if the customer demand at any time is zero. The excess heat generated by the fuel cell will simply be discharged through the existing radiator.

The system should be designed to meet the following specifications:

Flow: 0-10 gpm (1-2 gpm will maximize heat reclamation from the fuel cell)
Pressure: <= 30 psig
Temperature: (installation specific) with a flow rate of 1-2 gpm, the return temperature to the customer-supplied system will be approximately 140^{o}F
Available heat:

- 11,200 BTU/hr @ 2.5kWe
- 21,900 BTU/hr @ 4.0kWe
- 27,000 BTU/hr @ 5.0kWe

2. Define the fuel cell thermal output, and the thermal loads supported by the fuel cell.

Temperature: (installation specific) with a flow rate of 1-2 gpm, the return temperature to the customer-supplied system will be approximately 140^{o}F
Available heat:

- 11,200 BTU/hr @ 2.5kWe
- 21,900 BTU/hr @ 4.0kWe
- 27,000 BTU/hr @ 5.0kWe

3. State the operating modes of the thermal recovery system, continuous, intermittent, seasonal, etc.

Intermittent: Operated by a sensor/aquastat.

The fuel cell system is designed to operate normally if there is no CHP loop installed or if the customer demand at any time is zero. The excess heat generated by the fuel cell will simply be discharged through the existing radiator.

4. Describe the interconnection process of the fuel cell thermal recovery system to the facility.

   The CHP heat recovery loop is a customer-supplied system that circulates a heat transfer fluid (typically propylene-glycol/water mixture) from the fuel cell to the customer-supplied system using the heat (baseboard heat, hot water tank, etc.)

   Piping connections will be made from the domestic cold water line into an indirect hot water maker tank. This cold water will be heated by a closed-loop propylene-glycol/water mixture which circulates from the fuel-cell through the indirect hot water maker and returning back to the fuel-cell. The result is domestic hot water which will tie back into the existing storage tank adding more hot water to the system.

5. Provide photographs and engineering design drawings if available.

   At this time, we do not have engineering drawings available or photographs. We anticipate having drawings by the end of May, 2004.

11.0 Data Acquisition System

All operational data is sent automatically by the system (once per day) via modem/dial up connection to Plug Power where it is entered into the fleet database. Also, during every system shutdown, the unit automatically reports to Plug Power it's status, transmits data and a service call is then made.

Complete system operational data can be obtained directly from Plug Power or downloaded by a trained service technician with a laptop and RS232 connection cable. This data can be used for reporting and/or troubleshooting. Typical data used for reporting (non-sensitive) are run hours, power output, gas consumption, efficiency and availability.

We have completed a test run with the National Weather Service to provide the atmospheric data to document the environmental conditions in proximity to the installation site. A file attached to this submission contains the captured data on an hourly basis of numerous environmental parameters for the month of March 2004. Note that some observations may be more frequent than by the hour if environmental conditions are in the midst of change.

MDU would also like to install a standard gas meter upstream of the fuel cell, an electric meter downstream for the fuel cell and a Btu meter. These three devices will be read once a week and compared with the operational data that Plug is obtaining.

12.0 Economic Analysis

This preliminary economic analysis is on installing 1 Plug Power fuel cell at the Billings Armed Forces Reserve Center located in Billings Montana. For the natural gas pricing calculations the author used April of 2004 data. The electric rate was determined from the information given about a medium sized electric customers located on their web page at www.northwesternenergy.com/services/comparer.asp

The water heater efficiency was determined by looking at several Energy Factor (EV) ratings on the www.aceee.org web page. The Energy Factor ratings indicate overall efficiency and look at heat exchanger and burner efficiencies as well as heat loss from the tank. The author only believes burner

efficiencies are used to calculate the avoided cost on natural gas. Since heat is being rejected in the same water tank as the hot water heater, the author considered the heat loss from the tank a push. The author estimated efficiency at slightly more than the calculated EV values given for similar hot water heaters.

Listed below are the assumptions and calculations to derive at the avoided cost at installing a fuel cell at the Billings Armed Service Center.

Assumptions:

Conversions

1,000,000	Btu's = 1 dk
3,413	Btu's = 1 kWh
365	Day's = 1 Year
24	Hrs = 1 Day

Efficiencies & Unit Performance

26%	= Efficiency elec. fuel cell
70%	= Efficiency of htw. heater
50%	= CHP efficiency
90%	= Fuel cell availability
2.5	= kW set point

Cost

7.558	= $/dk
0.07	= $/kWh

Formulas

Runtime (hrs) = 24 (hrs/day)x365(days/year)x(fuel cell availability)

Avoided electric (kWh) = (runtime hrs)x(kW set point)

$$\text{Avoided natural gas (dk)} = \frac{[(\text{kW set point})/(\text{efficiency elec. fuel cell})\times(\text{CHP eff.} - \text{efficiency elec. fuel cell})\times(\text{runtime hrs})\times(3{,}413\ \text{Btu's/kWh})]}{[\text{efficiency htw heater} \times 1{,}000{,}000\ \text{Btu's/dk})]}$$

$$\text{Fuel Cell (dk)} = \frac{[(\text{kW set point})/(\text{efficiency elec. fuel cell})]\times(\text{runtime hrs})\times(3{,}413\ \text{Btu's/kWh})}{[1{,}000{,}000\ \text{Btu's/dk})]}$$

Avoided Cost ($) = [(avoided electric kWh x (0.07 $/kWh) + (avoided natural gas dk x 7.558 $/kWh)] - [fuel cell dk x (7.558 $/ dk)]

Calculations

Runtime annual (hrs)	7,884
Avoided Electric Consumption (kWh)	19,710
Avoided Natural Gas Consumption (dk)	88.68

Calculations Cont.

Annual Consumption Fuel Cell (dk)	258.66
Avoided Cost ($)	**94.99**

The estimated annual savings on installing one fuel cell for the Billings Armed Services Center came to approximately $95.00 per year. The low savings estimate is do to the low electric prices in Billings, MT. The gas and electric gas rates for Billings are fairly representative of the prices paid in Wyoming, North Dakota and South Dakota.

13.0 Kickoff Meeting Information

The Kickoff Meeting schedule is dependent upon the travel schedules of CERL representatives. The earliest we would be prepared to meet is the week on 5/17. Key project personnel will be in training at Plug Power in Latham, NY during the week of 5/24. Anytime the week of 5/31, and from that point forward would be acceptable for us. Please let us know your availability and who you would like to see there. At a minimum, we believe the following representatives from the following organizations should be present:

Montana-Dakota Utilities
NorthWestern Energy
Montana Army National Guard
Associated Construction Engineers
Wagner Mechanical
Ace Electric
Montana State University-Billings

It would also be helpful to know exactly where CERL would like to hold the meeting. Scheduling space and AV equipment at the university is fairly easy. The host site is about a 15-20 minute drive from campus. I am also willing to contact the POC at the host site and request space for the Kickoff Meeting. Finally, we would request that if CERL has a "sample agenda" from previous Kickoff Meetings that has worked well in the past, please forward it to us.

14.0 Status/Timeline

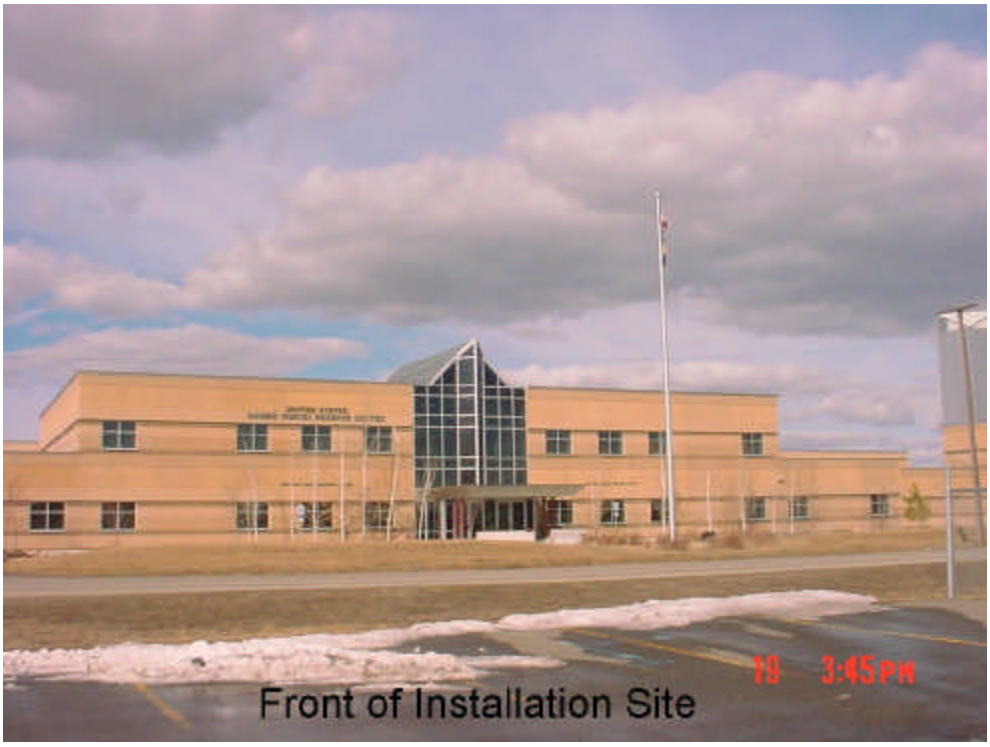
The project team took delivery of the fuel cell on April 5, 2004. It is currently stored within a secured facility in Billings at Montana-Dakota Utilities. To maintain continuity of possession, the project team drafted an MOU between MSU-B and MDU that is currently in force. The MOU is located in Appendix **D**.

Estimated Timetable of Events

Milestone	April '04	May '04	June '04	July '04	AUG '04	Sept '04	Jun '05	Jul '05	Sep '05
Contracts for subs and vendors	X								
Initial Project Description Report (Draft)	X								
Engineering/ Construction Drawings & Permitting		X							
Training of MDU personnel		X							
Kickoff Meeting			X						
Final Initial Project Description Report			X						
Site Preparation			X						
Fuel Cell Installation and Commissioni ng				X					
Midpoint Project Status Report (Draft)					X				
Acceptance Meeting					X				
Midpoint Project Status Report						X			
One year of fuel cell power							X		
Final Report (Draft)								X	
Site Restoration								X	
Final Report									X
Completion of Project									X

Appendix

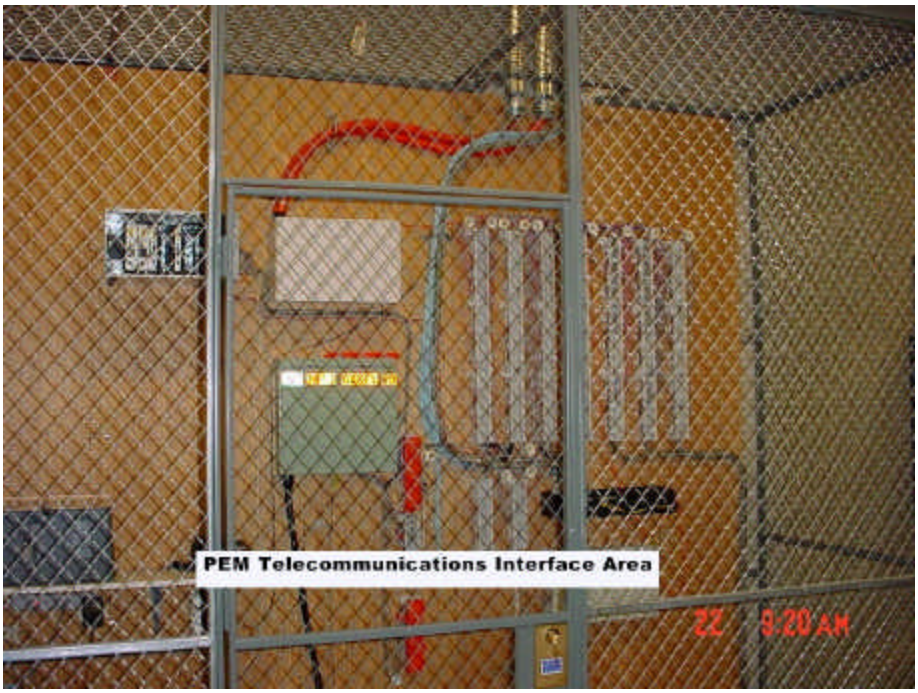
Appendix A



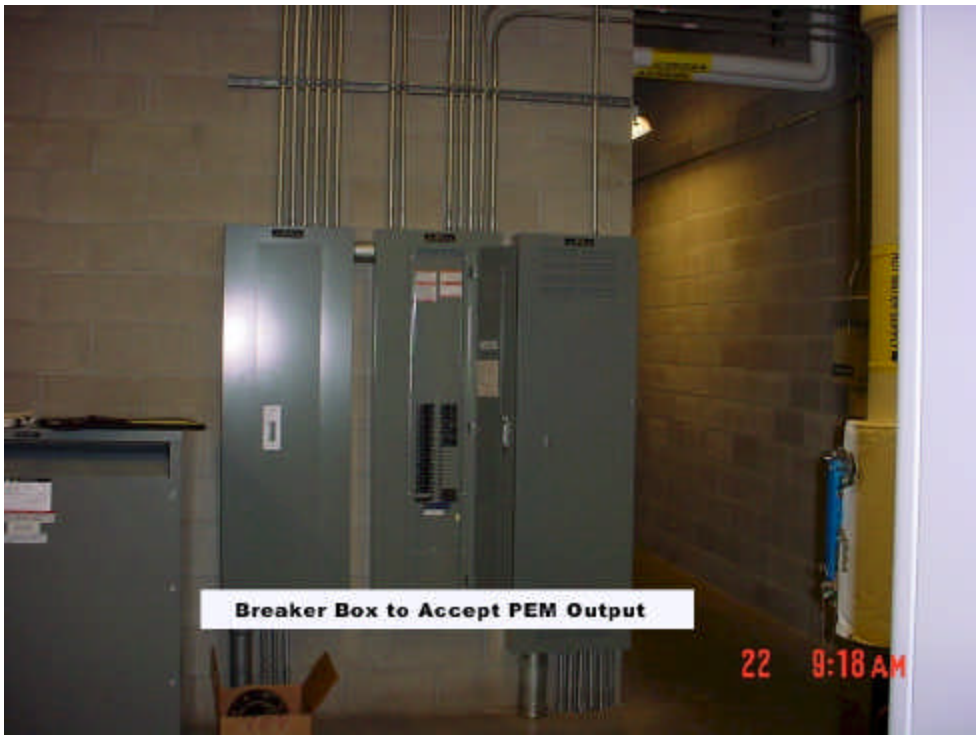
Appendix B


Mechanical/Utility: Possible PEM installation site
19 3:50 PM

Appendix C



Appendix C (continued)



Appendix D

Memorandum of Understanding

Montana State University-Billings (MSU-B)

And

Montana-Dakota Utilities (MDU)

As a partner with MSU-B for Solicitation # W9132T-04-R-0014, Proton Exchange Membrane Fuel Cell Demonstration at the Billings Armed Forces Reserve Center, MDU agrees to take delivery of the fuel cell and all of its associated components, if any, when they arrive in Billings, Montana. Fuel cell shipping is the responsibility of Plug Power of Latham, NY. MDU agrees to provide temporary storage of the fuel cell and its associated components until site prep is completed at the Reserve Center. MDU agrees to provide reasonable care and security during this period. MDU further agrees that it has in force adequate insurance coverage (min. $70,000) that can be used as a mechanism to compensate MSU-B in case of fire, flood, vandalism, theft, damage, etc.

March 29, 2004

C.A. Carey, MSU-B

Frank Durant ,MDU